Macrohyporia extensa and its synonym *Poria cocos*

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Daedalea extensa Peck is an earlier name for *Poria cocos* Wolf, the fungus commonly called tuckahoe. Descriptions of the basidiomes and cultures are presented. In the northern deciduous forests of eastern North America the fungus typically occurs as a trunk and butt rot of mature, old-growth trees. The basidiomes appear after the tree has died. Reports of the fungus from Manitoba, Saskatchewan, and Alberta require confirmation because of confusion with the Canadian tuckahoe, *Polyporus tuberaster* Fr. Both *D. extensa* and *Merulius sulphureus* Burt are transferred to *Macrohyporia*.

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Daedalea extensa Peck est un nom antérieur du *Poria cocos* Wolf, le champignon communément appelé tuckahoe. Ses basidiomes et ses caractères culturaux sont décrits. Dans les forêts décidues nordiques de l'est de l'Amérique du Nord, c'est typiquement un champignon de la pourriture du tronc et de la souche des vieux arbres matures. Les basidiomes apparaissent souvent après la mort de l'arbre. Les mentions de la présence du champignon au Manitoba, en Saskatchewan et en Alberta ne doivent pas être acceptées avant d'avoir été confirmées, à cause de la confusion possible avec le tuckahoe canadien, *Polyporus tuberaster* Fr. *D. extensa* et *Merulius sulphureus* sont tous les deux transférés au genre *Macrohyporia*.

[Traduit par le journal]

Some polypores, although originally well described, have remained obdurately of uncertain identity. *Daedalea extensa* Peck, described from western New York State (Peck 1891), has been one example. "It is suggestive of resupinate forms of *Trametes mollis*, but differs from it in the character of the pores, in the thicker subiculum and in the absence of any free margin" (Peck 1891, p. 21). Overholts (1919, p. 77), who evidently did not see Peck's specimen, was told by H. D. House of Albany that "nothing is left of the type ... except a few wood fragments with very slight indications of a fungous mycelium." Overholts thought that Peck's description suggested a species similar to *Trametes serialis* Fr. and, in an herbarium note with a specimen of *D. extensa* (Van Hook 2398 at NY), noted "possibly *Trametes hispida* Bagl." Murrill (1920, p. 110) reported a second locality, Indiana, for *D. extensa* and commented that the specimen (Van Hook 2398) agreed with Peck's "exceedingly good" description. Murrill (1920) and later J. R. Weir (in herbarium notes at MICH concerning a West Virginia collection) believed the type was lost. Type material still existed and a detailed account of it and D. V. Baxter's West Virginia specimen of *D. extensa* was presented by Lowe (1942, p. 96), the most recent discussion of the species.

Despite these reports no mention of *D. extensa* occurred in Overholts's (1953) manual of the North American polypores. Perhaps he considered the species to be better classed with the porias, a section of the polypores not treated in his manual.

In 1975 Lowe determined a Nova Scotia collection to be *D. extensa* and initiated a restudy of known specimens of *D. extensa*. In 1980 Ginns collected and cultured a fungus which was identical with the part of the Nova Scotia collection housed in DAOM. Descriptions of basidiomes and cultures are presented, new synonymy is proposed, and the epithet is transferred to *Macrohyporia* Johan. & Ryv., after we concluded that it was not congeneric with the lectotypes of either *Daedalea* Pers.:Fr. or *Poria* Pers. (see Donk 1974).

Methods

Microscopic data were obtained from sections of fresh and dried basidiomes in 2% KOH sometimes with phloxine. Melzer's reagent was used to test for amyloid and dextrinoid reactions, and cotton blue was used to determine cyanophily. Color codes are from the *Munsell book of color*, Munsell Color Co., Baltimore, MD., 1942. Cultures were studied according to the procedures of Nobles (1965). In addition five tests were used to determine the presence of extracellular laccase and (or) tyrosinase produced by actively growing mycelium. In these tests a drop of reagent was placed at several points on 3-week-old mats and any change in the color of the drop was recorded at 5 min, 1 h, and 3 h. The reagents were alcoholic solutions of *p*-cresol, guaiacol, gum guaiacum, syringaldazine, and tyrosine. Syringaldazine was prepared according to the directions given by Harkin *et al.* (1974) and the four other reagents were prepared according to Kaarik's (1965, p. 15) instructions.

Description

Macrohyporia extensa (Peck) comb. nov.
≡*Daedalea extensa* Peck, Annual report of the State Botanist [for] 1890. Bot. ed. From the 44th report of the N.Y. State Mus. Albany. p. 21. 1891.
=*Merulius albus* Burt, Ann. Mo. Bot. Gard. 4: 334. 1917, fide Ginns (1968, p. 1219).
=*Poria cocos* Wolf, J. Elisha Mitchell Sci. Soc. 38: 134–135. 1911, ut *Poria cocos* (Schw.) Wolf.
≡*Macrohyporia cocos* (Wolf) Johan. & Ryv., Trans. Br. Mycol. Soc. 72: 192. 1979.
=*Poria magnahypha* Overh., Pa. Agric. Exp. Stn. Tech. Bull. 418. p. 31. 1942, fide Lowe (1966).
=anamorph: *Sclerotium cocos* Schw., Nat. Ges. Leipzig Schr. 1: 56. 1822, fide Wolf (1922).
≡*Pachyma cocos* (Schw.) Fr., Syst. Mycol. 2: 242. 1823.

Basidiomes resupinate to subreflexed, becoming widely effuse, to 7 mm thick; margin narrow to several millimetres wide, cream color (paler than the hymenial surface), initially cottony, becoming matted or membranous, subreflexed (Fig. 10), thick and obtuse where extended beyond the edges of the ventral surface of the substrate or beyond the upper edge of the vertical surface of the substrate, this surface dark blackish brown (7.5YR3/2), granulose to crustose; dissepiments (Fig. 1) initially outlining angular to daedaleoid pores, one or two per millimetre, through vertical elongation sometimes forming conical or flattened teeth, up to 5 mm long, rather firm and rigid, the edges initially entire and wavy, becoming more or less fimbriate, when bruised in fresh condition staining pale brown and drying hard-ceraceous; context concolorous with trama or cream color at the base of the dissepiments becoming tan to grey brown (near 7.5YR4/2) toward the substratum, not xanthochroic, soft to firm-fibrous, dense, up to 2(–5) mm thick; hymenial surface lining pores and on surfaces of teeth, cream color (whiter than 2.5Y8/4), smooth, dry, pruinose.

Hyphal system dimitic. Subreflexed surface (Figs. 10–11) a rather dense palisade about 100 μm thick of broadly rounded hyphal tips 8–10 μm diam with wall, cell contents, and resinous incrusting particles a pale reddish brown; context of generative, skeletal and gloeoplerous hyphae; generative hyphae (Figs. 3 and 6), more or less gelatinized in KOH (Fig. 14), hyaline, subhyaline to pale olive brown, thin to moderately thick walled (Fig. 3), simple-septate, branched, 8–23 μm diam, other generatives infrequent, hyaline, thin walled, 3–10 μm diam; skeletals (Fig. 6) subhyaline, slightly refractive, moderately thick to thick walled, aseptate except for a few retraction septa near the apices, infrequently branched, (2–)3–8 m diam; gloeoplerous hyphae (Fig. 13) scattered, thin walled, sparsely branched, with oily-resinous, reddish brown contents, which when fresh stain black in cotton blue, 7–20 μm diam; tramal hyphae essentially vertically oriented with generatives hyaline, thin walled, septate, infrequently branched, 3–6 μm diam; skeletals (Figs. 15–16) subhyaline, moderately thick to thick walled, except thin walled over the apical 30 μm, the wall in the distal portion thickened 0.7 μm for about 70 μm, aseptate except for about five retraction septa in the apical 100 μm, the hyphal wall noticeably thickened (1–1.5 μm) and refractive at about the fifth septum behind the apex, rarely branched, 3–6 μm diam; gloeoplerous hyphae infrequent, with pale yellow brown contents, 3–6 μm diam; the sterile mouths of the pores or tips of the teeth composed of generative hyphae which have their tips swollen 2–3 μm broader than the hyphae; cystidia none; basidia (Fig. 7) narrowly clavate to clavate, 25–31 × 6–9.5 μm, sterigmata 2–(4); spores (Figs. 2 and 7) cylindrical to subboletoid, (7–)8–11 × 2.5–4 μm; spore wall hyaline, smooth, thin, nonamyloid, nondextrinoid, acyanophilous, with a blunt, rather large apiculus; spore print white.

In culture the mats grew rather slowly, 3.5–5 cm in radius at 6 weeks; at 4 weeks (Fig. 8) white, sometimes with pallid to pinkish buff patches up to 5 mm diam, appressed and sparse around the inoculum, but the pigmented patches denser, typically forming several indistinct fan-like radiating segments, but other mats weakly concentrically zonate; aerial growth (Fig. 9) patchy, raised about 0.5 mm, downy to cottony, with numerous hyaline droplets 0.5 mm diam on the mat surface; margin 0.5–1 cm wide, mounded, dense, raised 0.5–1 mm with the leading edge even but slightly wavy (Fig. 9, as viewed from above); agar neither bleached nor discolored; odor fragrant but not strong, resembling fenugreek. Tests for laccase and tyrosinase on five isolates were all negative.

Hyphae of the advancing edge of the mats hyaline, thin walled, 4–5 μm diam, broadening to 7 μm about 100 μm behind the hyphal tips, walls parallel, slightly wavy, not constricted at the septa, infrequently septate, simple-septate, the first septum 200–300 μm from the hyphal tip, branches rather frequent, about 10 occurring in the short (10–15 μm long), 3–4 μm diam apical cell; older areas of the mat composed of generative, gloeoplerous and skeletal hyphae; generatives variable, typically thin walled with some moderately thick walled, sometimes with constricted cytoplasm, hyaline, branched, simple-septate, 4–8 μm diam, other generatives with slightly refractive, moderately thick walls, often short celled (20–50 μm long), often constricted at the septa, 9–13 μm diam, the branches 4–8 μm diam, moderately thick walled; gloeoplerous hyphae similar to generatives but contents yellow brown, scattered but readily seen in the pigmented patches of the mats; skeletals (Fig. 12) at 4–5 weeks pale yellow, thick walled, slightly refractive, 2–3 (–4) μm diam, aseptate, typically composed of a relatively broad (3–4 μm diam) segment several hundred microns long with a few, slightly narrower branches, each up to several hundred microns long.

Swellings principally on the broader generative hyphae, globose, sometimes catenulate and the segment somewhat moniliform, up to 20(–30) μm diam, commonly appearing as bulges distending one side of a hyphal segment.

Culture code (Nobles 1965): 1.6.8.26.32.36.38.47. 50.54.

TYPE SPECIMENS EXAMINED: *Daedalea extensa*, New York State: Salamanca, on angiosperm wood, C. H. Peck (NYS lectotype, designated in Overholts (1919, p. 77). *Poria cocos*, North Carolina: near Raleigh, Spring 1922, on pine root in land being cleared for tobacco bed, F. A. Wolf (NCU 5377, here designated lectotype for *P. cocos* Wolf) and basidiome "grown in a test tube" (Wolf in herbarium note) from 5377 (NCU 5391).

ADDITIONAL PERTINENT SPECIMENS FILED AS *D. extensa*: INDIANA: Bloomington, over *Quercus* sp. and *Liroidendron tulipifera*, van Hook 2398 (NY); WEST VIRGINIA: Clendenin, on *Fagus*, D. V. Baxter 1-6712 (MICH); NOVA SCOTIA: Kentville, on large log of *Betula* sp., K. A. Harrison 12678 (samples deposited at ACAD, BPI, C, CUP, DAOM 154421, FH, GB, K, KRA, L, LE, MICH, NY, NYS, PC, PR, S, SYRF, UPS, W, and herb. H. Jahn, B.D.R.); ONTARIO: Renfrew Co.: Dore Lake: Shaw Woods, on large log of *Acer saccharum*, J. Ginns 4754 (DAOM 177616); Parry Sound Dist.: Parry Sound: Indian Docks, on *Ulmus* sp., R. F. Cain, TRTC 31328 (DAOM 31287).

CULTURES EXAMINED: Filed as *Poria cocos*, MINNESOTA: Deer River, rot in *Abies balsamea*, L. L. Sluzalis, FP 58593-R (DAOM 22953); PENNSYLVANIA: Elk Co., from *Acer* sp., W. A. Campbell *et al.*, FP 71284-A (DAOM 22955); SOUTH CAROLINA: Walhalla, from tuckahoe on healthy *Pinus echinata*, W. A. Campbell & B. Zak, FP 90886-T (DAOM 22957); BRITISH COLUMBIA: Vancouver Island: Skutz Falls, from root rot in *Pseudotsuga menziesii*, D. C. Buckland *et al.*, SF 109 (DAOM 21018), and filed as *D. extensa* DAOM 177616 which is cited in detail above.

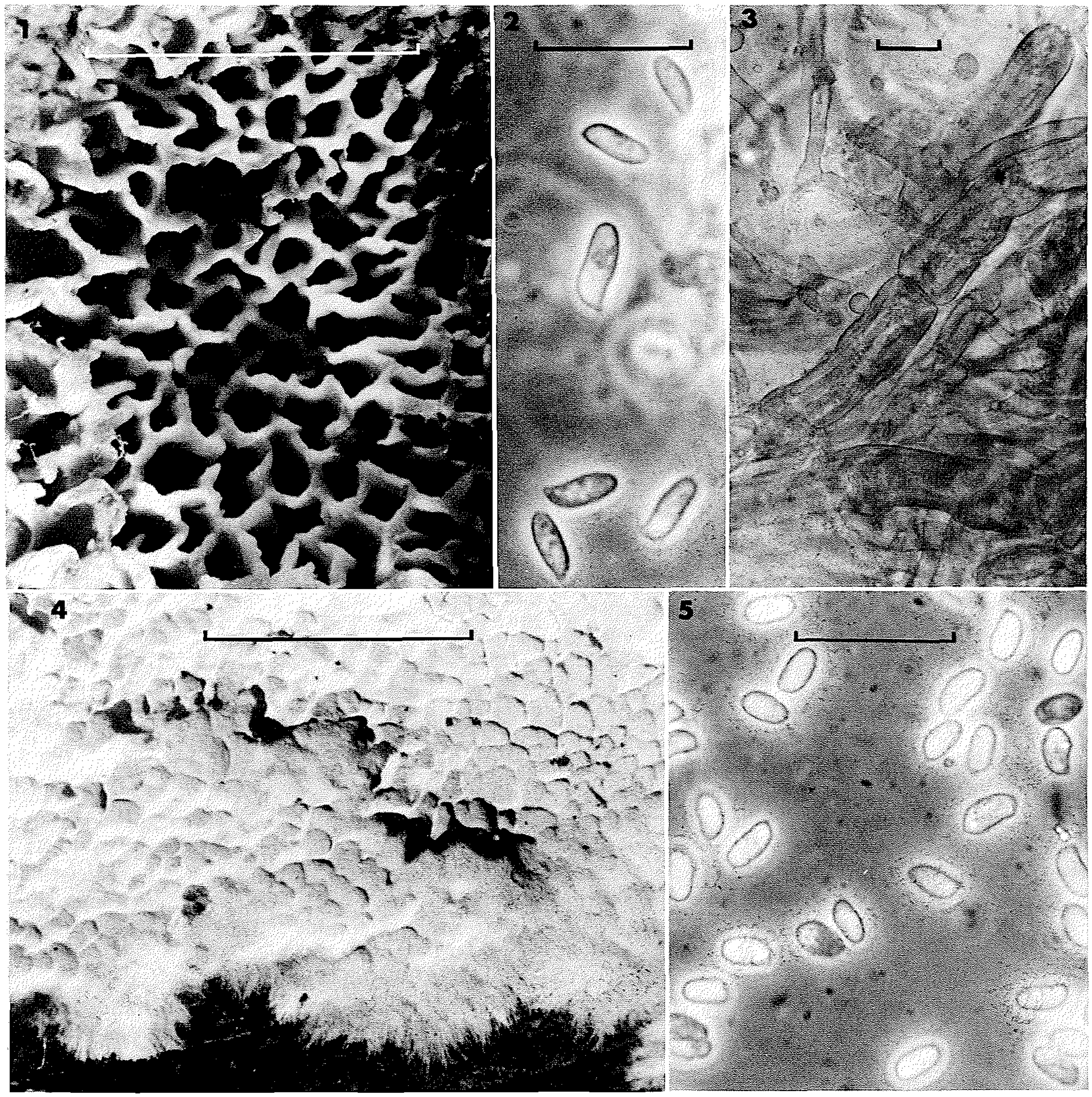
Discussion

The name *Poria cocos* Wolf is placed in synonymy with *Macrohyporia extensa* because the *Rules of botanical nomenclature 1978* (article 59) indicate that the correct name is the earliest legitimate name typified by the perfect state (= teleomorph). Despite the fact that the name *Sclerotium cocos* was proposed in 1822 for the sclerotial state, the teleomorph was not described until 1891 when Peck named it *Daedalea extensa*. Later the epithet *cocos* was misapplied to the teleomorph by Wolf (1922) in proposing what he stated to be a new combination, "*Poria cocos* (Schw.) *comb. nov*." In fact he proposed a new name (see article 59) which should be cited as *P. cocos* Wolf (see also Donk 1974, p. 300). The specimen herein designated as lectotype for *P. cocos* Wolf was pictured by Wolf (1922) on the right in his plate 35.

The type specimen of *D. extensa* has been nearly destroyed by insects. Thus we could not confirm the features of Peck's (1891) original description. However, we were able to characterize the hyphae. The unusual type of hyphae and the close agreement of our specimens with the features given by Peck convinced us that we had specimens of *D. extensa*.

In North America this fungus has been reported as *Poria cocos* from coast to coast and from the southern United States into the southern one-third of Canada (Conners 1967; Lowe 1966; Lowe and Gilbertson 1961, 1962). Some of these records are suspect as two fungi have been confused, a result of similar common names, i.e., tuckahoe for *P. cocos* and Canadian tuckahoe for *Polyporus tuberaster* Fr.; moreover both produce structures that have been called sclerotia. Baxter (1949, p. 14) cited the Canadian tuckahoe in giving the occurrence of *Poria cocos*; thus his records of *P. cocos* from Manitoba and Saskatchewan certainly referred to *Polyporus tuberaster*. The report of *Poria cocos* from Saskatchewan in Gilbertson (1956, p. 74) was taken from the literature, presumably from Baxter (1949). Lowe and Gilbertson's (1962, p. 492) and Lowe's (1966, p. 28) Saskatchewan records were probably from Baxter. Lowe and Gilbertson's (1962) report from Alberta presumably was based on their examination of a specimen because no earlier literature records are known. *Macrohyporia cocos* has been reported from Africa (Ryvarden and Johansen 1980) and Tibet (Zang 1980, p. 174 as *P. cocos*).

Macrohyporia extensa, particularly the sclerotial state, has been collected on a variety of plants (Davidson and Campbell 1954 as *P. cocos*). The distribution and host records of *M. extensa* are unusual in that they are based on the occurrence of sclerotia or on the isolation of cultures from decay in live trees and only infrequently on collections of basidiomes. Sclerotia have not been found in the deciduous forests of northeastern North America or in the coniferous forests of the western mountains. In the deciduous forests the fungus apparently exists for decades causing a butt or root rot of large-diameter trees, fruiting only after the host is dead and has fallen. Collection 177616 extended for nearly



FIGS. 1–5. *Macrohyporia extensa*. DAOM 177616. Fig. 1. Pore mouths of fresh specimen. Fig. 2. Basidiospores. Fig. 3. Broad, moderately thick-walled, simple-septate generative hyphae and narrow, thick-walled, branched skeletal hyphae from context. Figs. 4–5. *Macrohyporia sulphurea*. Type at FH. Fig. 4. Margin and shallow pores. Fig. 5. Basidiospores. Scale in Figs. 1 and 4 equals 5 mm; in Figs. 2, 3, and 5 equals 20 μm.

4 m in bark crevasses along the underside of a log 1 m in diameter and several other collections were reported to have been associated with old, large-diameter trees. The pathology of *M. extensa* (as *P. cocos*) was reviewed by Davidson and Campbell (1954), Stillwell (1955), and Lowe (1966). In Ontario, Basham and Morawski (1964) found it to occasionally cause a butt or trunk rot in *Abies*, *Acer*, *Betula*, *Fagus*, *Ostrya*, *Picea*, and *Tsuga*. Atwell (1956) found *M. extensa* (as *Poria cocos*) to be more destructive in stored poplar bolts than in the living tree. In storage the rot involved both heartwood and sapwood, whereas in living trees the rot was confined largely to the heartwood. In a related study, Fritz (1954) had reported a similar behavior for *M. extensa* (as *P. cocos*) and observed "rampant" growth in bolts as well as the ability to spread to previously uninfected bolts.

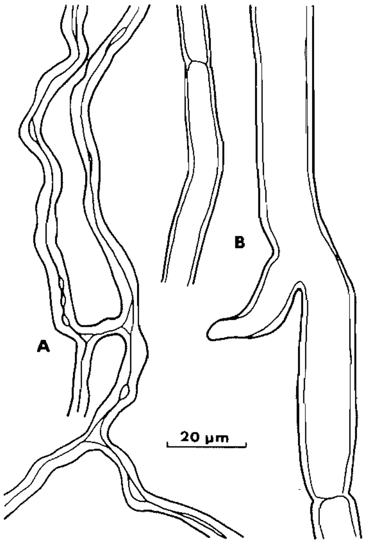


FIG. 6. *Macrohyporia extensa.* Segments of context hyphae. A, skeletal; B, narrow and broad generatives. From DAOM 177616.

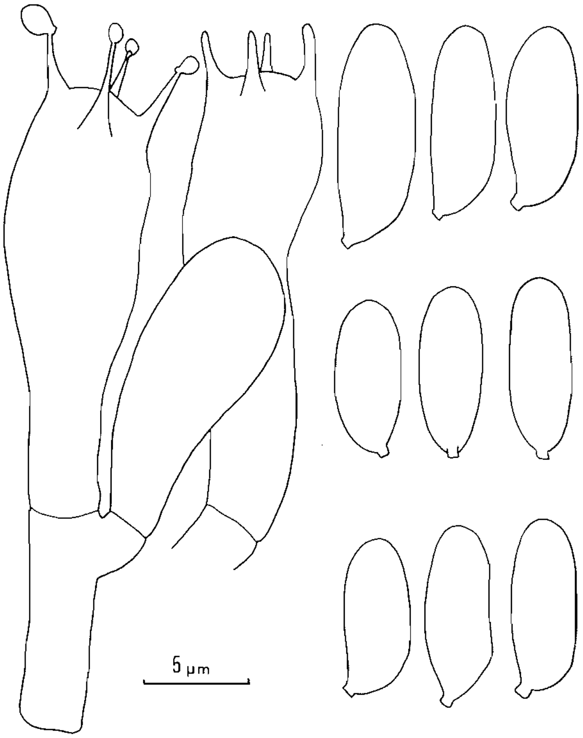


FIG. 7. *Macrohyporia extensa.* Basidia, one immature basidium, and spores. From DAOM 177616.

She concluded that *M. extensa* may cause extensive decay in storage piles, especially because it has such a destructive effect on cellulose (i.e., it causes a brown rot).

The blackening of the gloeoplerous hyphae in cotton blue is an uncommon reaction in the polypores. The other species of *Macrohyporia* that have gloeoplerous hyphae are known only from dried specimens and it is not known whether their gloeoplerous hyphae stain in cotton blue.

The spores germinated readily and quickly on 1.25% malt agar. They swelled to 13 × 7.5 µm before a germ tube was seen.

The cultural features (as reported above) differed in a few respects from the earlier reports. Our tests for tyrosinase were negative, whereas Stalpers (1978) recorded tyrosinase activity. Stalpers found skeletal hyphae up to 3 µm in diameter and unbranched and marginal hyphae up to 15 µm. Some differences such as the lack of fruiting and slow growth rate in our isolates were attributed to the rather thick layer of malt agar that was used. In earlier reports (Davidson *et al.* 1942; Baxter 1949) cultures often produced fertile basidia and the mycelium grew across a petri plate in 2–3 weeks.

The cultural characters of *M. extensa* are unusual. No other wood rot fungus has the combination of negative oxidase reactions, simple-septate hyphae, and skeletal hyphae. In addition it is unusual to find hyphae as broad as those in *M. extensa*. Nobles (1958, p. 902) on the basis of negative oxidase reactions and simple-septate hyphae listed the fungus, as *P. cocos*, in a group with 15 other wood rots, but none of them seem to be congeneric with *M. extensa*.

The relationship of *M. extensa* to other polypores lies not with *Trametes hispida*, *T. mollis*, or *T. serialis*, as suggested by Peck (1891) and Overholts (1919), but with *Poria inflata* Overh. and *P. dictyopora* (Cooke) Cooke, as Lowe (1966) noted. Johansen and Ryvarden (1979, p. 192) segregated *P. cocos*, *P. dictyopora*, and *P. inflata* from *Poria* and placed them in the newly proposed genus *Macrohyporia*. The distinguishing feature of *Macrohyporia* was a combination of characters which were shared by the three species. The characters were lignicolous, effused basidiomes of

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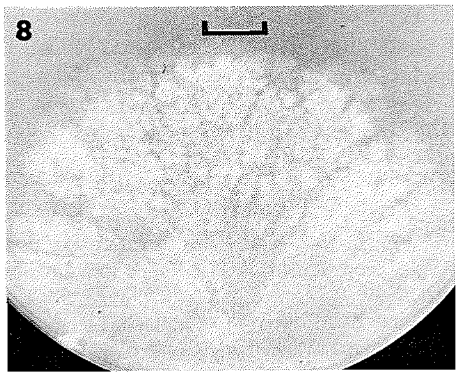
FIGS. 8–16. *Macrohyporia extensa.* DAOM 177616, except Figs. 5 and 7 from DAOM 22957. Figs. 8–9. Mycelial mat at 4 weeks. Figs. 10–11. Subreflexed section of basidiome with dark blackish brown crust (arrowhead) and enlargement of crust depicting incrusted hyphal palisade, respectively. Fig. 12. Segment of branched (at arrowheads) skeletal hypha from 5-week-old culture. Fig. 13. Segment of gloeoplerous hypha stained with phloxine. Fig. 14. Gelatinous walls of broad hyphae. Fig. 15. Tramal skeletal hypha about 200 µm behind apex. Fig. 16. Apex of some hypha in Fig. 15 showing retraction septa and thin wall. Scale in Figs. 9–10 equals 1 cm; in Figs. 11–16 equals 20 µm.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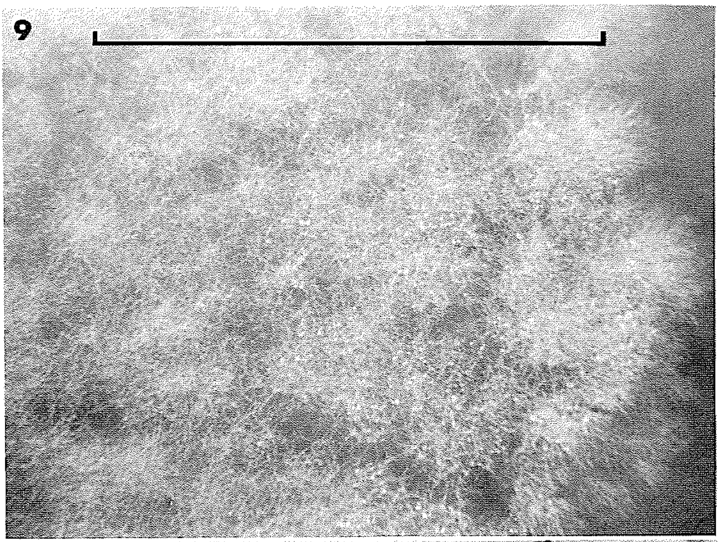
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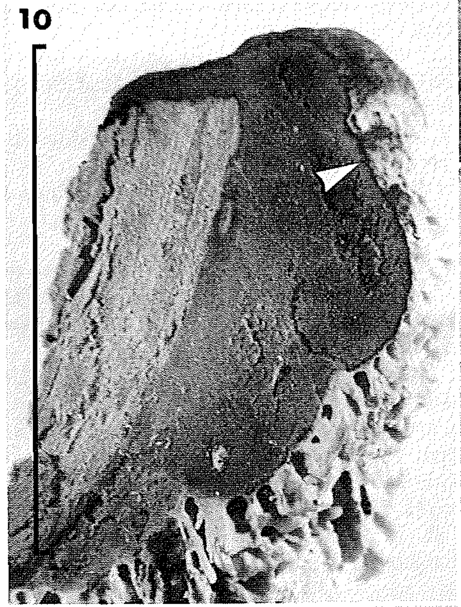
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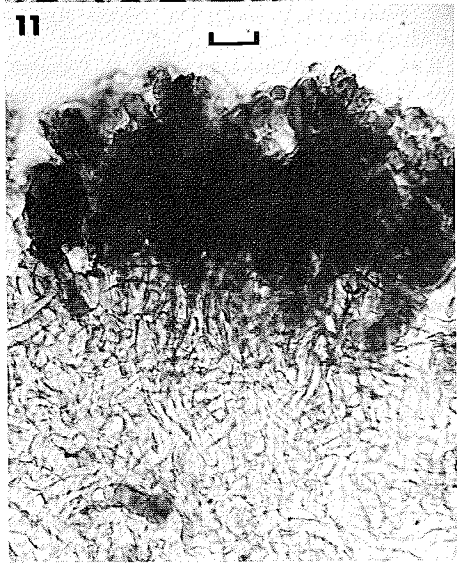
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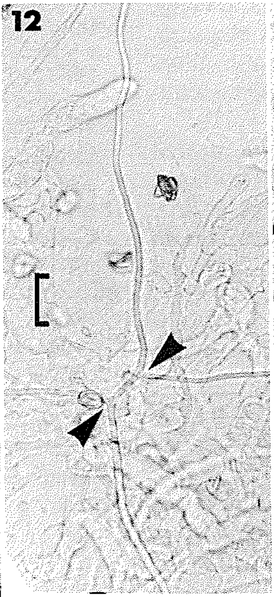
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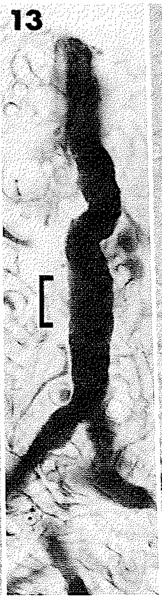
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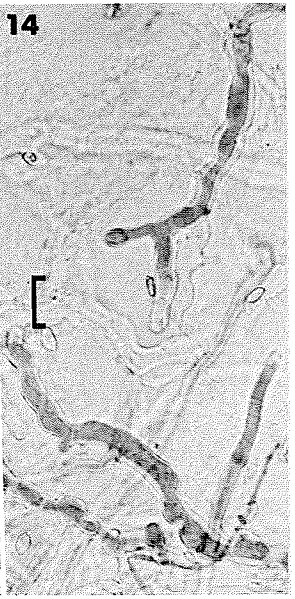
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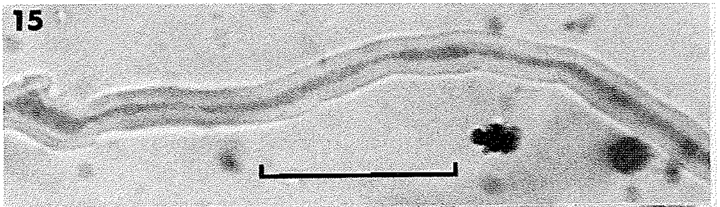
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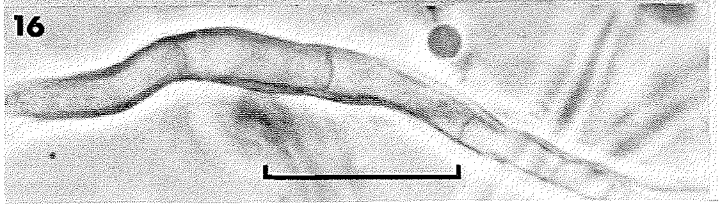
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brittle to hard texture when dry, a pore surface cream to ochraceous or pale brown and dull, rather large pores (one to five per millimetre or larger), a thin context with simple-septate hyphae up to 20 μm broad and binding hyphae or strongly branched, thick-walled generative hyphae of large diameter, and spores subglobose to ellipsoid with walls smooth, thin to slightly thickened.

Merulius sulphureus Burt (Figs. 4 and 5) also belongs in *Macrohyporia*. In a study of the type, Ginns (1968, pp. 1218–1219) compared this fungus with *Poria cocos* but was uncertain of its correct generic disposition. *Merulius sulphureus* has a monomitic hyphal system with hyphae hyaline, simple-septate with the occasional clamp connection on the marginal hyphae, with contents of scattered, small (–1 μm), yellow granules, the walls 0.5–1 μm thick or up to 2 μm thick on the broad hyphae, 3–8(–13) μm diam; gloeoplerous hyphae similar to the generatives differing only in having dense, yellow contents; spores (Fig. 5) in profile cylindrical oblong, some with the base bent, in face view broadly ellipsoid, (4.5–)6.5–8(–10.5) × 3.5–5 μm, the wall subhyaline, thin, smooth, nonamyloid, nondextrinoid, acyanophilous, with a minute apiculus.

Macrohyporia inflata also has a monomitic hyphal system, but the hyphae have thicker walls and are much more branched, contorted, and woven. The yellow hymenial surface is distinctive for ***Macrohyporia sulphurea*** (Burt) comb. nov. (basionym: *Merulius sulphureus* Burt, Ann. Mo. Bot. Gard. 4: 333. 1917. ≡*Byssomerulius sulphureus* (Burt) Lindsey in Gilbertson, R. L., *et al.* (1974)). The type specimen of *M. sulphurea* was reexamined for the purpose of comparing it with *M. extensa*. Owing to the many morphological similarities the two fungi were considered to be congeneric. One feature argues against their being congeneric. *Macrohyporia extensa* and *M. inflata* are associated with a brown rot, whereas *M. sulphurea* is reportedly (Ginns 1968; Gilbertson *et al.* 1974, 1976) associated with a white rot. The type of decay caused by the type species of *Macrohyporia*, *M. dictyopora* (Cooke) Johan. & Ryv. is not known. The type of decay that a fungus causes is considered taxonomically significant at the generic level, so the genera of lignicolous Basidiomycetes contain species which cause either a white rot or a brown rot but never a mixture of some brown rot and some white rot species, unless the genus is heterogeneous (cf. Gilbertson 1980, pp. 32–33).

Lindsey (Gilbertson *et al.* 1974) transferred *M. sulphurea* to *Byssomerulius* Parm., but the species has features that deviate from that genus. First there is no indication on the type specimen of *M. sulphurea* that the hymenium was initially smooth and later became folded, and the pores have sterile mouths, indicating a polyporoid type of hymenial development rather than the corticioid type which is typical of *Byssomerulius*. Second the hymenium in *M. sulphurea* lacks the phlebioid basidial arrangement typical of *Byssomerulius* species (cf. Ginns 1968, Fig. 4) and Eriksson and Ryvarden (1973, Fig. 82) for illustrations of the two types).

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